This document includes Section 3.0 – CVN 68 Class, Vessels: Nuclear Steam Propulsion Aircraft Carriers of the Draft EPA Report "Surface Vessel Bilgewater/Oil Water Separator Environmental Effects Analysis Report" published in 2003. The reference number is: EPA-842-D-06-018

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Section 3.0 – CVN 68 Class, Vessels: Nuclear Steam Propulsion Aircraft Carriers

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SECTION 3.0 – CVN 68 CLASS

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3.1 INTRODUCTION

This Environmental Effects Analysis Report (EEAR) presents surface vessel bilgewater discharge from the Uniform National Discharge Standards (UNDS) vessel group, "Vessels with Nuclear Steam Propulsion." Currently, the only nuclear-powered surface vessels in the Armed Forces are the ENTERPRISE and NIMITZ Class aircraft carriers. The two classes in this vessel group total 10 ships, nine active ships and one ship under construction. Eight of the nine active ships and the ship under construction are NIMITZ Class carriers; the other active ship is an ENTERPRISE Class carrier. The NIMITZ Class (CVN 68) was selected as the representative vessel class for this group. For more information about the vessel group and the selection of the representative vessel class used in this environmental effects analysis (EEA), see *Vessel Grouping and Representative Vessel Class Selection for Surface Vessel Bilgewater/Oil-Water Separator Discharge* (Navy and EPA, 2001g).

The composition of bilgewater varies among vessel classes. Shipboard wastestreams, such as steam condensate, boiler blowdown, drinking fountain water, and sink drainage located in various machinery spaces are designed to drain into the bilge on some ships. Leaks from tanks, pump packing glands as well as leaking piping, valves, and flanges contribute to the bilge in varying amounts, depending upon their age and maintenance histories. Spills from the ship's propulsion and auxiliary systems, runoff from housekeeping (e.g. washing of deckplates or equipment) as well as precipitation and greenwater, also can enter the bilge. The water may be contaminated with oily constituents comprised primarily of JP-5 fuel (used for powering aircraft), F-76 (used to power emergency diesel generators), 2190TEP lube oil (used for lubricating main engines and auxiliary equipment), and MIL-D-9250 lube oil (used to lubricate emergency diesel generators). To a lesser extent, hydraulic oil (used for elevators, cranes, and winches) and various grades of grease lubricants (used on pulleys, cables, valves, and other components) may be found in the bilgewater. Other significant contributions to water constituents include detergents (or surfactants), corrosion products from metal surfaces and discharges from sinks used to perform maintenance on engine room equipment. Bilgewater sampling during Uniform National Discharge Standards (UNDS) Phase I identified more than 25 priority pollutants, including metals, organics, and bioaccumulative contaminants of concern (BCC) known to cause persistent toxic effects to aquatic and terrestrial life and humans (EPA and DoD, 1999).

The CVN Class vessels have nuclear reactors that supply heat to steam generators, which in turn drive the main propulsion turbines. The steam generators require blowdowns; however, the resulting wastewater discharges directly overboard, rather than to the bilge. For more information on nuclear steam blowdowns, refer to the *Phase I Uniform National Discharge Standards for Vessels of the Armed Forces Technical Development Document* (EPA, 1999).

Bilgewater discharges from nuclear powered vessels were characterized from sampling data and supplemented by process knowledge from equipment experts and vessel drawings. Examples of sample data and process knowledge include end-of-pipe (EOP) chemical constituent concentrations, suspended solids and oil and grease (hexane extractable material (HEM)) concentrations, field measurements of pH, flow rates, and descriptive information such as color and odor. The Navy analyzed samples for constituent concentration from the wastestream before processing (i.e., baseline discharge) and after marine pollution control device (MPCD) treatment. Details on the characterization of this discharge are contained in the *Characterization Analysis Report: Surface Vessel Bilgewater/OWS Discharge* (hereafter referred to as the Bilgewater Characterization Analysis Report (ChAR)) (Navy and EPA, 2003).

3.2 DIFFERENCES FROM THE EEA METHODOLOGY

The analysis of discharge information and presentation of results in this report are in accordance with the methodology contained in *Environmental Effects Analysis Guidance for Phase II of the Uniform National Discharge Standards for Vessels of the Armed Forces* (Navy and EPA, 2000e, hereafter referred to as the EEA guidance manual). The EEA for surface vessel bilgewater/OWS discharge from vessels with nuclear steam propulsion did not require any variation from the methodology contained in the EEA guidance manual.

3.3 SUMMARY OF EEA RESULTS

This section summarizes the results of the eight technical tasks conducted for the baseline discharge and each MPCD discharge.

3.3.1 Baseline Discharge

The baseline discharge has been subjected to a full EEA as a basis for comparing MPCD options; however, this vessel group does not release the untreated baseline discharge into the receiving waters. Currently, a gravity-coalescence OWS system processes bilgewater produced by this vessel group (see Section 3.3.2) prior to overboard discharge.

3.3.1.1 Discharge Characterization Data

Baseline discharge characterization data for vessels with nuclear steam propulsion were assembled from sampling data and supplemented by process knowledge from equipment experts and vessel drawings. The sampling data for this vessel group were taken from the USS JOHN STENNIS (CVN 74 Class). The Bilgewater ChAR (Navy and EPA, 2003) contains more information on the collection and analysis of discharge characterization data.

The data analysis for this discharge identified 12 constituents of concern (COC) and five narrative categories in the baseline discharge. In accordance with the EEA guidance manual (Navy and EPA 2000e), COCs are defined as:

- Constituents that exceed one or more numeric water quality criteria (WQC) at EOP or any narrative WQC;
- Constituents identified as BCCs; or
- Constituents with EOP hazard quotients (HQ) > 1

Appendix B lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at the edge of the mixing zone (EOMZ), and indicates whether they are elimination or reduction BCCs.

3.3.1.2 Discharge Comparison to Criteria

The composition of bilgewater is characterized by a set of constituent concentrations compiled from sample data, as described in the Bilgewater ChAR (Navy and EPA, 2003). In the comparison of constituent data for baseline discharge to numeric WQC, the EOP concentrations of seven constituents exceeded 78 WQC (Table 3-1). Appendix A summarizes the comparison of the COC concentrations to corresponding Federal and State WQC. The baseline discharge also exceeded five narrative WQC categories (Table 3-2). Appendix C provides the complete narrative WQC analysis.

Table 3-1. Constituents Exceeding Numeric Water Quality Criteria Identified in the Baseline Discharge[1] from Vessels with Nuclear Steam Propulsion (CVN 68)

Constituents	Concentration at EOP (μg/L)	Criteria Exceeded	Strictest Criterion (μg/L)	State(s) with Strictest Criterion
Cadmium	5.4E+00	2 of 13	5.0E+00	NC, PR
Copper	2.6E+02	24 of 24	2.4E+00	MS, CT, GA
Iron	5.2E+02	1 of 1	3.0E+02	FL
Mercury	9.2E-02	3 of 12	2.5E-02	FL, NC, GA
Nickel	3.0E+02	23 of 24	8.3E+00	FL, NC, PR
Selenium	1.2E+01	1 of 21	1.0E+01	PR
Zinc	1.6E+03	24 of 24	5.0E+01	PR

[1] *Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater is treated by a gravity coalescence OWS.*

Table 3-2. Narrative Water Quality Criteria Categories Exceeded by the Baseline Discharge[1] from Vessels with Nuclear Steam Propulsion (CVN 68)

Narrative Constituent with Applicable Numeric Endpoint	Result
BOD	Fail
Nutrients	Fail
Phosphorus (6.0E+01 μg/L)	3.5E+03 μg/L
Ammonia (1.0E+01 μg/L)	1.4E+02 μg/L
Nitrate/Nitrite (1.5E+01 μg/L)	5.2E+02 μg/L
Total Nitrogen (3.0E+02 μg/L)	1.5E+03 μg/L
Oil and Grease (HEM)	Fail
EOP (5.0E+03 μg/L)	5.1E+04 μg/L
No Sheen (1.5E+04 μg/L EOP)	5.1E+04 μg/L
EOMZ (1.5E+01 μg/L)	5.9E+03 μg/L
Suspended Solids (2.5E+04 μg/L)	Fail - 4.4E+04 μg/L
Turbidity/Colloidal Matter	Fail

[1] *Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater is treated by a gravity coalescence OWS.*

3.3.1.3 Discharge Toxicity (Hazard Index)

Based on curvilinear-grid hydrodynamic 3D (CH3D) model results, the minimum dilution factor at the EOMZ for the baseline discharge was estimated to be 8.636. This dilution factor was applied to the EOP concentration of the constituents to determine discharge toxicity at the EOMZ. The input parameters for this model run are presented in Appendix D, and the dilution graph, indicating the minimum dilution factor, is presented in Appendix E. For more information about the UNDS modeling method, see the Technical Approach for Pierside Modeling to Support UNDS EEA Phase II (Navy and EPA, 2001f).

Table 3-3 summarizes the results of the HQ and hazard index (HI) calculations for the baseline discharge constituents with an EOP HQ greater than 1. For more information on the use of the HI calculations in the UNDS program, see *Method for Assessing the Toxicity of Multiple Contaminants in Discharges from Vessels of the Armed Forces Uniform National Discharge Standards (UNDS) Phase II* (Navy and EPA 2001b). The constituents are listed from highest to lowest HQ at EOMZ.

Table 3-3. Constituents with Hazard Quotients >1 at End of Pipe, Ranked by Edge of Mixing Zone Hazard Quotient, in the Baseline Discharge[1] from Vessels with Nuclear Steam Propulsion (CVN 68)

Constituents	HQ at EOMZ
Total Sulfide	5.1E+01
Copper	1.4E+01
Oil and Grease (HEM[2])	7.2E+00
Zinc	2.1E+00
Sulfate	1.8E+00
Nitrate/Nitrite	8.6E-01
Nickel	4.8E-01
Iron	2.0E-01
HI of above constituents	7.8E+01
Total Discharge HI	**7.8E+01**

[1] *Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater has been treated by a gravity coalescence OWS.*

[2] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001a).*

The discharge HI at EOMZ is 78, with the above constituents comprising approximately 99 percent of the total discharge HI.

An HI of 1.0 or less is the level considered to be protective of aquatic life from acute toxic effects of the discharge. This level is equivalent to the United States Environmental Protection Agency (EPA) WQC for aquatic life [i.e., Criterion Maximum Concentration (CMC)]. The CMC is intended to protect most species most of the time (EPA 1991). This level of protection is set near the concentration resulting in no observable effect on the most sensitive aquatic species, which EPA has determined will adequately protect aquatic communities. At HI values less than or equal to 1.0, the potential for acute toxic effects to aquatic species is considered to be at an acceptable level.

3.3.1.4 Non-Indigenous Species Release

The potential for the baseline discharge to introduce non-indigenous species (NIS) is expected to be low because "*there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances*" (EPA and DoD, 1999).

3.3.1.5 Bioaccumulative Contaminants of Concern

Table 3-4 lists the EOP concentrations of the five constituents from the baseline discharge identified as elimination and reduction BCCs. BCCs for the UNDS program are divided into two types: those designated for elimination by various international, Federal, and State programs, and those designated for reduction by United States permit and cleanup programs.

Table 3-4. Bioaccumulative Contaminants of Concern Identified in the Baseline Discharge[1] from Vessels with Nuclear Steam Propulsion (CVN 68)

Elimination BCCs (µg/L)		Reduction BCCs (µg/L)	
Cadmium	5.4E+00	Bis (2-ethylhexyl) Phthalate	2.2E+01
Mercury	9.2E-02	Copper	5.7E+02
		Zinc	1.6E+03
		Selenium	1.2E+01

[1] *Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater is treated with a gravity coalescence OWS.*

3.3.1.6 Constituent Mass Loading and Toxic Pound Equivalents

Determination of discharge constituent mass loading and toxic pound equivalents (TPE) values are based on discharge generation volume and location of vessel operation. The CVN 68 (representative vessel class) is pierside approximately 147 days per year, 3 days per year transiting inside 12 nm, and 215 days per year operating underway outside 12 nm (Navy and EPA, 2003).

Table 3-5 presents mass loading and TPEs for the COCs identified in the baseline discharge for the nine active vessels in this vessel group while operating inside 12 nm. The COCs are listed from highest to lowest TPE and comprise 99 percent of the total discharge TPE. Appendix F presents the complete discharge constituent mass loading and TPE data. TPE results presented in Table 3-5 do not include the chronic toxicity contribution from oil and grease (HEM) constituents, because there are insufficient data available to develop a defensible toxic weighting factor (TWF) for oil and grease (HEM). The chronic toxicity contributions from oil and grease (HEM) constituents could potentially be estimated by extrapolation of HQ and HI results (refer to Section 3.3.1.3). The HI calculations indicate that oil and grease (HEM) constituents contribute approximately nine percent of the total discharge HI, a measure of the total acute toxicity of bilgewater. Therefore, oil and grease (HEM) constituents are assumed to contribute nine percent of the total chronic toxicity for this analysis.

Table 3-5. Mass Loading and Toxic Pound Equivalents for the Constituents of Concern Identified in the Baseline Discharge[1] from Vessels with Nuclear Steam Propulsion (CVN 68)

Discharge Constituent	Mass Loading (lb/yr)	Toxic Pound Equivalents
Total Sulfide	2.0E+03	5.7E+03
Copper	1.4E+02	2.5E+02
Nickel	7.4E+01	5.1E+01
Zinc	4.0E+02	2.8E+01
Nitrate/Nitrite	1.3E+02	1.2E+01
Mercury	2.2E-02	2.6E+00
Cadmium	1.3E+00	8.8E-01
Sulfate	1.2E+05	6.7E-01
Selenium	2.8E+00	2.3E-01
Iron	1.3E+02	2.2E-01
Bis (2-Ethylhexyl) Phthalate	5.5E+00	[2]
COC TPE Total		6.1 E+03
Total Discharge TPE		6.1 E+03

[1] *Baseline discharge from this vessel group is not discharged overboard. Discharge occurs only after the bilgewater is treated by a gravity coalescence OWS.*

[2] *No TPE value is calculated for this constituent. As discussed in the EEA Guidance Manual (Navy and EPA, 2000e), the use of a proxy value indicated that the contribution of this constituent to the total value is relatively small.*

3.3.1.7 Other Potential Environmental Impacts

Currently, all vessels in this group process bilgewater through a gravity coalescence OWS system before discharge. The environmental effects from the use of the gravity coalescence OWS are discussed in Section 3.3.2 below.

If CHT is employed, the baseline discharge is held onboard and then transferred to a shore facility for recycling or disposal without passing through an OWS system. The offloaded bilgewater is then treated at a properly permitted facility and is subject to applicable Federal, State, and local disposal regulations.

3.3.1.8 Summary of Environmental Effects

The analysis of the baseline discharge from vessels with nuclear steam propulsion identified 12 COCs and five narrative categories. Appendix B lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs. Appendix F presents the annual mass loading and TPE data for this discharge.

In summary, the baseline discharge:

- Exceeds 78 numeric WQC and five narrative criteria categories;
- Has an EOMZ HI of 78;

- Has low potential to introduce NIS;
- Contains two elimination and four reduction BCCs; and
- Has a total discharge TPE inside 12 nm of 6,100, with the COCs comprising approximately 99 percent of the total.

3.3.2 Primary Treatment MPCD

For purposes of bilgewater analysis, gravity coalescence type oil water separators (OWSs) represent the three primary MPCD options determined to be feasible aboard the CVN 68 Class vessels (refer to Section).

As described in Navy and EPA (2000b), gravity coalescence type OWSs operate on the principle that due to the immiscibility and specific gravity differences of oil and water, the oil will separate from the water and droplets will coalesce into a separate layer of fluid. Oily waste is pumped from the oily waste holding tank (OWHT) through the OWS, which contains coalescing material. Coalescing material is typically polypropylene, an oleophilic polymer that may be in the form of parallel plates or loose packed media. As the oil droplets, entrained in the influent, flow through the OWS, they will come into contact with the coalescing material and adhere to it. As more droplets attach to the polymer, they will come in contact with each other and form larger droplets (coalesce). These droplets will break free from the plates or media and rise to the surface of the OWS tank where they typically collect in an oil tower. The OWS has sensors that detect the presence of oil in the oil tower and trigger the OWS to automatically pump the collected oil to a waste oil tank. The treated effluent can be tested for oil content by an oil content monitor. If the effluent contains higher than the desired oil content, it may be returned to the OWHT for further processing. If the oil and grease (HEM) content of the effluent is less than 15 ppm, the effluent may be discharged overboard.

Most vessels of the CVN 68 Class are equipped with two parallel-plate type gravity coalescing OWSs that each operate at a flow rate of 50 gpm (see Appendix D). Gravity coalescers placed on Navy vessels are certified in accordance with NAVSEAINST 9593.2, OPNAVINST 5090.1B, and DoD Directive 6050.15. During normal pierside operation, CVN 68 Class vessel bilgewater is transferred to a shoreside treatment facility. On occasion, where shoreside facilities are not available, two OWSs typically discharge intermittently through a common single port located above the waterline. The discharge duration is approximately 17 hours once every three days.

3.3.2.1 Discharge Characterization Data

Characterization data for the primary treatment discharge from vessels with nuclear steam propulsion were assembled from sampling data and supplemented by process knowledge from equipment experts and vendors. The Bilgewater ChAR (Navy and EPA, 2003) provides more information on the collection of discharge characterization data.

The data collection for this discharge identified ten COCs and five narrative categories in the primary treatment discharge. Appendix B lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs.

3.3.2.2 Discharge Comparison to Criteria

The composition of bilgewater is characterized by a set of constituent concentrations compiled from sample data, as described in the Bilgewater ChAR (Navy and EPA, 2003). In the comparison of constituent data for the primary treatment discharge to numeric WQC, the EOP concentrations of six constituents exceeded 77 WQC (Table 3-6). Appendix A summarizes the comparison of COC concentrations to the corresponding Federal and State numeric WQC. The primary treatment discharge also exceeded five narrative WQC categories (Table 3-7). Appendix C provides the complete narrative WQC analysis.

Table 3-6. Constituents Exceeding Numeric Water Quality Criteria Identified in the Primary Treatment Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Constituents	Concentration at EOP (μg/L)	Criteria Exceeded	Strictest Criterion (μg/L)	State(s) with Strictest Criterion
Cadmium	5.1E+00	2 of 13	5.0E+00	NC, PR
Copper	1.6E+02	24 of 24	2.4E+00	MS, CT, GA
Iron	4.7E+02	1 of 1	3.0E+02	FL
Mercury	5.2E-02	3 of 12	2.5E-02	FL, NC, GA
Nickel	1.7E+02	23 of 24	8.3E+00	FL, NC, PR
Zinc	8.8E+02	24 of 24	5.0E+01	PR

Table 3-7. Narrative Water Quality Criteria Categories Exceeded by the Primary Treatment Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Narrative Constituent with Applicable Numeric Endpoint	Result
BOD	Fail
Nutrients	Fail
Phosphorus (6.0E+01 μg/L)	1.8E+03 μg/L
Ammonia (1.0E+01 μg/L)	1.3E+02 μg/L
Nitrate/Nitrite (1.5E+01 μg/L)	2.7E+02 μg/L
Total Nitrogen (3.0E+02 μg/L)	1.5E+03 μg/L
Oil and Grease (HEM)	Fail
EOP (5.0E+03 μg/L)	2.3E+04 μg/L
No Sheen (1.5E+04 μg/L EOP)	2.3E+04 μg/L
EOMZ (1.5E+01 μg/L)	2.7E+03 μg/L
Suspended Solids (2.5E+04 μg/L)	Fail - 4.2E+04 μg/L
Turbidity/Colloidal Matter	Fail

3.3.2.3 Discharge Toxicity (Hazard Index)

Based on CH3D model results, the minimum dilution factor at the EOMZ for the primary treatment discharge was predicted to be 8.636. This dilution factor was applied to the EOP concentration of the constituents to determine discharge toxicity at the EOMZ. The input parameters for this model run are presented in Appendix D, and the dilution graph, indicating the minimum dilution factor, is presented in Appendix E.

Table 3-8 summarizes the HQ and HI calculations for the constituents identified in the primary treatment discharge to have an HQ greater than 1 at the EOP. The constituents are listed from highest to lowest HQ at EOMZ.

Table 3-8. Constituents with Hazard Quotients > 1 at End of Pipe, Ranked by Edge of Mixing Zone Hazard Quotient, in the Primary Treatment Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Constituents	HQ at EOMZ
Total Sulfide	3.1E+01
Copper	8.3E+00
Oil and Grease (HEM[1])	3.2E+00
Sulfate	3.2E+00
Zinc	1.1E+00
Nitrate/Nitrite	4.5E-01
Nickel	2.6E-01
Iron	1.8E-01
HI of Above Constituents	**4.7E+01**
Total Discharge HI	**4.7E+01**

[1] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001a).*

The discharge HI at the EOMZ is 47, with the above constituents comprising approximately 99 percent of the total discharge HI.

3.3.2.4 Non-Indigenous Species Release

The potential for the baseline discharge to introduce NIS is expected to be low because *"there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances"* (EPA and DoD, 1999). The processing of the baseline bilgewater by a primary treatment MPCD will not increase, and may further reduce, the potential for the discharge to introduce NIS.

3.3.2.5 Bioaccumulative Contaminants of Concern

Table 3-9 lists the EOP concentrations of the four constituents identified in the primary treatment discharge as elimination and reduction BCCs.

Table 3-9. Bioaccumulative Contaminants of Concern Identified in the Primary Treatment Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Elimination BCCs (µg/L)		Reduction BCCs (µg/L)	
Cadmium	5.1E+00	Copper	3.4E+02
Mercury	5.2E-02	Zinc	8.8E+02

3.3.2.6 Constituent Mass Loading and Toxic Pound Equivalents

Table 3-10 summarizes the mass loading calculations and TPE for the COCs identified in the bilgewater treated by primary treatment for this vessel group while operating inside 12 nm. The COCs are listed from highest to lowest TPE and comprise 97 percent of the total discharge TPE. Appendix F presents the complete discharge constituent mass loading and TPE data.

TPE results presented in Table 3-10 do not include the chronic toxicity contribution from oil and grease (HEM) constituents, because there are insufficient data available to develop a defensible TWF for oil and grease (HEM). The chronic toxicity contributions from oil and grease (HEM) constituents could potentially be estimated by extrapolation of HQ and HI results (refer to Section 3.3.2.3). The HI calculations indicate that oil and grease (HEM) constituents contribute approximately seven percent of the total discharge HI, a measure of the total acute toxicity of bilgewater. Therefore, oil and grease (HEM) constituents are assumed to contribute seven percent of the total chronic toxicity for this analysis.

Table 3-10. Mass Loading and Toxic Pound Equivalents for the Constituents of Concern Identified in the Primary Treatment Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Discharge Constituent	Mass Loading (lb/yr)	Toxic Pound Equivalents
Total Sulfide	1.2E+03	3.4E+03
Copper	8.4E+01	1.5E+02
Nickel	4.1E+01	2.8E+01
Zinc	2.1E+02	1.5E+01
Nitrate/Nitrite	6.6E+01	6.1E+00
Mercury	1.3E-02	1.5E+00
Sulfate	2.2E+05	1.2E+00
Cadmium	1.3E+00	8.4E-01
Iron	1.1E+02	1.9E-01
COC TPE Total		**3.6E+03**
Total Discharge TPE		**3.7E+03**

3.3.2.7 Other Potential Environmental Impacts

Primary treatment creates two waste streams: the aqueous fraction that is discharged overboard, and the oil fraction that is directed to the onboard waste oil holding tank. The environmental impacts of the aqueous fraction are evaluated above. The oil fraction is treated ashore at a properly permitted facility and subject to applicable Federal, State, and local disposal regulations.

3.3.2.8 Summary of Environmental Effects

The analysis of the primary treatment discharge from vessels with nuclear steam propulsion identified ten COCs and five narrative categories. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs. Appendix F presents the annual mass loading and TPE data for this discharge.

In summary, the primary treatment discharge:

- Exceeds 77 numeric WQC and five narrative criteria categories;
- Has a discharge HI at EOMZ of 47;
- Has low potential to introduce NIS;
- Contains two elimination and two reduction BCCs; and
- Has a total discharge TPE inside 12 nm of 3,700, with the COCs comprising approximately 97 percent of the total.

3.3.3 Primary Treatment plus Filter Media

For purposes of bilgewater analysis, gravity coalescence OWSs represent the three primary MPCD options for this vessel group (see Section 3.1). Secondary treatment options, such as the use of filter media, are therefore analyzed with gravity coalescence as primary treatment.

As described in the *Draft Surface Vessel Bilgewater MPCD Screen-Control Device, MPCD Option Group: Filter Media* (Navy and EPA, 2001d), filter media are substances that selectively remove constituents (e.g., organics and metals) from wastewater. The media have an affinity for a particular constituent(s). When passed through the filter media, these constituents can be removed, typically through adsorption and/or absorption, from bilgewater. The types of media studied for this MPCD option group include activated carbon, polypropylene, resin bonded glass fiber, cellulose, humic acid, and synthetic polymers. Aboard large vessels such as the CVN 68 Class, filter media are stored in multiple replaceable canisters used in series.

Primary treatment plus filter media is not currently practiced aboard vessels within this vessel group.

3.3.3.1 Discharge Characterization Data

Characterization data for the primary treatment plus filter media discharge from vessels with nuclear steam propulsion were assembled from sampling data and supplemented by process knowledge from equipment experts and vendors. The Bilgewater ChAR provides more information on the collection of discharge characterization data (Navy and EPA, 2003).

The data collection for this discharge identified nine COCs and three narrative categories in the primary treatment plus filter media discharge. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs.

3.3.3.2 Discharge Comparison to Criteria

The composition of bilgewater is characterized by a set of constituent concentrations compiled from sample data, as described in the Bilgewater ChAR (Navy and EPA, 2003). In the comparison of constituent data for primary treatment plus filter media discharge to numeric WQC, the EOP concentrations of five constituents exceed 76 WQC (Table 3-11). Appendix A summarizes the comparison of the COC concentrations to corresponding Federal and State numeric WQC. The primary treatment plus filter media discharge also exceeded three narrative WQC categories (Table 3-12). Appendix C provides the complete narrative WQC analysis.

Table 3-11. Comparison of Constituent Concentrations Exceeding Numeric Water Quality Criteria for Primary Treatment plus Filter Media Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Constituents	Calculated Concentration at EOP (μg/L)[1]	Criteria Exceeded	Strictest Criterion (μg/L)	State(s) with Strictest Criterion
Cadmium	5.1E+00	2 of 13	5.0E+00	NC, PR
Copper	1.6E+02	24 of 24	2.4E+00	MS, CT, GA
Mercury	5.2E-02	3 of 12	2.5E-02	FL, NC, GA
Nickel	1.3E+02	23 of 24	8.3E+00	FL, NC, PR
Zinc	5.3E+02	24 of 24	5.0E+01	PR

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

Table 3-12. Narrative Water Quality Criteria Categories Exceeded by the Primary Treatment plus Filter Media Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Narrative Constituent with Applicable Numeric Endpoint	Result
BOD	Fail
Nutrients	Fail
Phosphorus (6.0E+01 μg/L)	1.8E+03 μg/L
Ammonia (1.0E+01 μg/L)	1.3E+02 μg/L
Nitrate/Nitrite (1.5E+01 μg/L)	1.6E+02 μg/L
Total Nitrogen (3.0E+02 μg/L)	1.5E+03 μg/L
Oil and Grease (HEM)	Fail
EOP (5.0E+03 μg/L)	6.8E+03 μg/L
No Sheen (1.5E+04 μg/L EOP)	6.8E+03 μg/L
EOMZ (1.5E+01 μg/L)	7.9E+02 μg/L

3.3.3.3 *Discharge Toxicity (Hazard Index)*

Based on CH3D model results, the minimum dilution factor at the EOMZ for the primary treatment plus filter media discharge was predicted to be 8.636. This dilution factor was applied to the EOP concentration of the constituents to determine discharge toxicity at the EOMZ. The input parameters for this model run are presented in Appendix D, and the dilution graph, indicating the minimum dilution factor, is presented in Appendix E.

Table 3-13 summarizes the HQ and HI calculations for constituents identified in the primary treatment plus filter media discharge that have an HQ greater than 1 at EOP. The constituents are listed from highest to lowest HQ at EOMZ.

Table 3-13. Constituents with Hazard Quotients > 1 at End of Pipe, Ranked by Edge of Mixing Zone Hazard Quotient, in the Primary Treatment plus Filter Media Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Constituents	HQ at EOMZ
Total Sulfide	6.1E+00
Copper	4.1E+00
Sulfate	3.2E+00
Oil and Grease (HEM[1])	9.5E-01
Zinc	6.8E-01
Nitrate/Nitrite	2.7E-01
Nickel	2.0E-01
HI of Above Constituents	**1.6E+01**
Total Discharge HI	**1.6E+01**

[1] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001a).*

The discharge HI at EOMZ is 16, with the above constituents comprising 99 percent of the total HI.

3.3.3.4 Non-Indigenous Species Release

The potential for the baseline discharge to introduce NIS is expected to be low because *"there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances"* (EPA and DoD, 1999). As discussed in Section 3.3.2.4, the processing of the baseline bilgewater by a primary treatment OWS may reduce the potential for the discharge of NIS to the receiving waters. While CVN 68 Class vessels may not currently use a secondary treatment device for bilgewater, the use of a secondary treatment option may further reduce the potential to release NIS.

3.3.3.5 3.3.5 Bioaccumulative Contaminants of Concern

Table 3-14 lists the EOP concentrations of the four constituents in the primary treatment plus filter media discharge identified as elimination and reduction BCCs.

Table 3-14. Bioaccumulative Contaminants of Concern Identified in the Primary Treatment plus Filter Media Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Elimination BCCs (µg/L)		Reduction BCCs (µg/L)	
Cadmium	5.1E+00	Copper	1.7E+02
Mercury	5.2E-02	Zinc	5.3E+02

3.3.3.6 Constituent Mass Loading and Toxic Pound Equivalents

Table 3-15 summarizes the mass loading and TPE for the COCs identified in the primary treatment plus filter media discharge for this vessel group while operating inside 12 nm. The COCs are listed from highest to lowest TPE and comprise approximately 91 percent of the total discharge TPE value. Appendix F presents the complete discharge constituent mass loading and TPE data.

TPE results presented in Table 3-15 do not include the chronic toxicity contribution from oil and grease (HEM) constituents, because there are insufficient data available to develop a defensible TWF for oil and grease (HEM). The chronic toxicity contributions from oil and grease (HEM) constituents could potentially be estimated by extrapolation of HQ and HI results (refer to Section 3.3.3.3). The HI calculations indicate that oil and grease (HEM) constituents contribute approximately six percent of the total discharge HI, a measure of the total acute toxicity of bilgewater. Therefore, oil and grease (HEM) constituents could potentially be assumed to contribute six percent of the total chronic toxicity for this analysis.

Table 3-15. Mass Loading and Toxic Pound Equivalents for the Constituents of Concern Identified in the Primary Treatment plus Filter Media Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Discharge Constituent	Mass Loading (lb/yr)	Toxic Pound Equivalents
Total Sulfide	2.5E+02	6.9E+02
Copper	4.2E+01	7.6E+01
Nickel	3.1E+01	2.1E+01
Zinc	1.3E+02	8.9E+00
Nitrate/Nitrite	4.0E+01	3.7E+00
Mercury	1.3E-02	1.5E+00
Sulfate	2.2E+05	1.2E+00
Cadmium	1.3E+00	8.4E-01
COC TPE Total		**8.0E+02**
Total Discharge TPE		**8.8E+02**

3.3.3.7 Other Potential Environmental Impacts

Primary treatment plus filter media creates three waste streams: the aqueous fraction that is discharged overboard following treatment, the oil fraction that is directed to the vessel's waste oil holding tank, and the solid waste composed of used filters. The environmental impacts of the aqueous fraction are evaluated above; there are no other known impacts to the receiving environment. The oil fraction is treated at a properly permitted facility and the used filters are subject to applicable Federal, State, and local disposal regulations.

3.3.3.8 Summary of Environmental Effects

The analysis of the primary treatment plus filter media discharge from vessels with nuclear steam propulsion identified nine COCs and three narrative categories. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs. Appendix F presents the annual mass loading and TPE data for this discharge.

In summary, the primary treatment plus filter media discharge:

- Exceeds 76 numeric WQC and three narrative criteria categories;
- Has a discharge HI at EOMZ of 16;
- Has low potential to introduce NIS;
- Contains two elimination and two reduction BCCs; and
- Has a total discharge TPE inside 12 nm of 880, with the COCs comprising approximately 91 percent of the total.

3.3.4 Primary Treatment plus Membrane Filtration

For purposes of bilgewater analysis, gravity coalescence type OWSs represent the three primary MPCD options for this vessel group (see Section 3.1). Secondary treatment options, such as the use of membrane filtration, are therefore analyzed as being used in conjunction with gravity coalescence.

As described in the *Surface Vessel Bilgewater MPCD Screen-Control Device, MPCD Option Group: Membrane Filtration* (Navy and EPA, 2001e), semi-permeable membranes are filtration systems that allow the passage of water, ions, or small molecules, but prohibit the passage of larger molecules (e.g., oil). Membrane filtration devices separate high molecular weight constituents from fluids by forcing the fluid through very small pores of a polymeric or inorganic membrane (LaGrega *et al.*, 1994). The membrane filtration MPCD option group consists of various types of membranes including nanofiltration (NF), ultrafiltration (UF), and microfiltration (MF). Membrane filtration devices (NF, UF, and MF) are classified according to the size of the contaminant they remove from the fluid.

3.3.4.1 Discharge Characterization Data

Characterization data for the primary treatment plus membrane filtration discharge from vessels with nuclear steam propulsion were assembled from sampling data and supplemented by process knowledge from equipment experts and vendors. The Bilgewater ChAR provides more information on the collection and synthesis of discharge characterization data (Navy and EPA, 2003).

The data collection for this discharge identified eight COCs and three narrative categories in the primary treatment plus membrane filtration discharge. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs.

3.3.4.2 Discharge Comparison to Criteria

The composition of bilgewater is characterized by a set of constituent concentrations compiled from sample data, as described in the Bilgewater ChAR (Navy and EPA, 2003). In the comparison of constituent data for the primary treatment plus membrane filtration discharge to numeric WQC, the EOP concentrations of four constituents exceeded 74 numeric WQC (Table 3-16). Appendix A summarizes the comparison of COC concentrations to the corresponding Federal and State numeric WQC. The primary treatment plus membrane filtration discharge also exceeded three narrative WQC categories (Table 3-17). Appendix C provides the complete narrative WQC analysis.

Table 3-16. Comparison of Constituent Concentrations Exceeding Numeric Water Quality Criteria for Primary Treatment plus Membrane Filtration Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Constituents	Calculated Concentration at EOP (μg/L)[1]	Criteria Exceeded	Strictest Criterion (μg/L)	State(s) with Strictest Criterion
Copper	1.6E+02	24 of 24	2.4E+00	MS, CT, GA
Mercury	5.2E-02	3 of 12	2.5E-02	FL, NC, GA
Nickel	1.8E+02	23 of 24	8.3E+00	FL, NC, PR
Zinc	8.6E+02	24 of 24	5.0E+01	PR

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

Table 3-17. Narrative Water Quality Criteria Categories Exceeded by the Primary Treatment plus Membrane Filtration Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Narrative Constituent with Applicable Numeric Endpoint	Result
BOD	Fail
Nutrients	Fail
Phosphorus (6.0E+01 μg/L)	1.8E+03 μg/L
Ammonia (1.0E+01 μg/L)	1.3E+02 μg/L
Nitrate/Nitrite (1.5E+01 μg/L)	2.7E+02 μg/L
Total Nitrogen (.0E+02 μg/L)	1.5E+03 μg/L
Oil and Grease (HEM)	Fail
EOP (5.0E+03 μg/L)	8.5E+03 μg/L
No Sheen (1.5E+04 μg/L EOP)	8.5E+03 μg/L
EOMZ (1.5E+01 μg/L)	9.8E+02 μg/L

3.3.4.3 Discharge Toxicity (Hazard Index)

Based on CH3D model results, the minimum dilution factor at the EOMZ for the primary treatment plus membrane filtration discharge was predicted to be 8.636. This dilution factor was applied to the EOP concentration of the constituents to determine discharge toxicity at the EOMZ. The input parameters for this model run are presented in Appendix D, and the dilution graph, indicating the minimum dilution factor, is presented in Appendix E.

Table 3-18 presents the HQ and HI calculations for constituents identified in the primary treatment plus membrane filtration discharge to have an HQ greater than 1 at EOP. The constituents are listed from highest to lowest HQ at EOMZ.

Table 3-18. Constituents with Hazard Quotients > 1 at End of Pipe, Ranked by Edge of Mixing Zone Hazard Quotient, in the Primary Treatment plus Membrane Filtration Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Constituents	HQ at EOMZ
Copper	4.8E+00
Sulfate	3.2E+00
Oil and Grease (HEM[1])	1.2E+00
Zinc	1.1E+00
Nitrate/Nitrite	4.5E-01
Nickel	2.8E-01
HI of Above Constituents	**1.1E+01**
Total Discharge HI	**1.1E+01**

[1] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001a).*

The total discharge HI at the EOMZ is 11, with the above constituents comprising 99 percent of the total discharge HI.

3.3.4.4 Non-Indigenous Species Release

The potential for the baseline discharge to introduce NIS is expected to be low because "*there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances*" (EPA and DoD, 1999). The processing of the baseline bilgewater by a primary treatment MPCD will not increase, and may further reduce, the potential for the discharge to introduce NIS to the receiving waters. While CVN 68 Class vessels may not currently use a secondary treatment device for bilgewater, the use of a secondary treatment option may further reduce the potential to release NIS.

3.3.4.5 Bioaccumulative Contaminants of Concern

Table 3-19 lists the concentrations of the four constituents from the primary treatment plus membrane filtration discharge identified as elimination and reduction BCCs.

Table 3-19. Bioaccumulative Contaminants of Concern Identified in the Primary Treatment plus Membrane Filtration Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Elimination BCCs (μg/L)		Reduction BCCs (μg/L)	
Cadmium	1.0E+00	Copper	2.0E+02
Mercury	5.2E-02	Zinc	8.6E+02

3.3.4.6 Constituent Mass Loading and Toxic Pound Equivalents

Table 3-20 summarizes the mass loading calculations and TPE for the COCs identified in the primary treatment discharge for this vessel group while operating inside 12 nm. COCs are listed from highest to lowest TPE and comprise approximately 67 percent of the total discharge TPE value. Another source of TPE contribution includes boron. Appendix F presents the complete constituent mass loading and TPE data.

Total discharge TPE results presented in Table 3-20 do not include the chronic toxicity contribution from oil and grease (HEM) constituents, because there are insufficient data available to develop a defensible TWF for oil and grease (HEM). The chronic toxicity contributions from oil and grease (HEM) constituents could potentially be estimated by extrapolation of HQ and HI results (refer to Section 3.3.4.3). The HI calculations indicate that oil and grease (HEM) constituents contribute approximately 11 percent of the total discharge HI, a measure of the total acute toxicity of bilgewater. Therefore, oil and grease (HEM) constituents are assumed to contribute 11 percent of the total chronic toxicity for this analysis.

Table 3-20. Mass Loading and Toxic Pound Equivalents for the Constituents of Concern Identified in the Primary Treatment plus Membrane Filtration Discharge from Vessels with Nuclear Steam Propulsion (CVN 68)

Discharge Constituent	Mass Loading (lb/yr)	Toxic Pound Equivalents
Copper	4.8E+01	8.8E+01
Nickel	4.3E+01	2.9E+01
Zinc	2.1E+02	1.5E+01
Nitrate/Nitrite	6.6E+01	6.1E+00
Mercury	1.3E-02	1.5E+00
Sulfate	2.2E+05	1.2E+00
Cadmium	2.5E-01	1.7E-01
COC TPE Total		**1.4E+02**
Total Discharge TPE		**2.1E+02**

3.3.4.7 Other Potential Environmental Impacts

Primary treatment plus membrane filtration creates two waste streams: the aqueous fraction and the oil fraction. The aqueous fraction is evaluated above; there are no other known impacts to the receiving environment. The oil fraction is treated at a properly permitted facility.

3.3.4.8 Summary of Environmental Effects

The analysis of the primary treatment plus membrane filtration discharge from vessels with nuclear steam propulsion identified eight COCs and three narrative categories. Appendix A lists the EOP concentrations of the COCs, their corresponding acute WQC, HQs at EOMZ, and indicates whether they are elimination or reduction BCCs. Appendix F presents the annual mass loading and TPE data for this discharge.

In summary, the primary treatment plus membrane filtration discharge:

- Exceeds 74 numeric WQC and three narrative criteria categories;
- Has a discharge HI at EOMZ of 11;
- Has low potential to introduce NIS;
- Contains two elimination and two reduction BCCs; and
- Has a total discharge TPE inside 12 nm of 210, with the COCs comprising approximately 67 percent of the total.

3.3.5 Collection, Holding, and Transfer (CHT)

Collection, holding, and subsequent transfer of bilgewater involves either shore disposal facilities or waste offload barges or processing of bilgewater beyond 12 nm. Shore disposal involves transfer of wastes to permitted treatment facilities either directly through a shoreside piping connection, or via tank trucks or waste offload barges. CHT does not include any treatment or volume reduction of raw bilgewater on board the vessel. In a typical CHT system, wastewater drains to the bilge or is transferred to a designated holding tank where it is retained until either the vessel returns to port or transits beyond 12 nm.

CHT is in use, to some extent, on all vessels that generate bilgewater, including the CVN 68 Class. All CVN Class vessels have OWS systems and use them prior to discharge when CHT is not being practiced. While moored pierside in ports where shore facilities are available, CVN 68 Class vessels practice CHT by transferring bilgewater to a properly permitted shoreside facility. If shore facilities are unavailable, or the vessel is operating outside 12 nm, bilgewater is processed through an OWS and then discharged (See Section 3.3.2 on primary treatment OWS). Additional information on this MPCD is provided in *Surface Vessel Bilgewater MPCD Screen-Control Device, MPCD Option Group: Collection, Holding, and Transfer* (Navy and EPA, 2001c).

3.3.5.1 Discharge Characterization Data

CHT does not directly release wastewater to the receiving waters within 12 nm. Refer to the Bilgewater ChAR for more information on the collection of characterization data (Navy and EPA, 2003).

3.3.5.2 Discharge Comparison to Criteria

Because CHT does not directly release wastewater to the receiving waters within 12 nm, no numeric or narrative WQC are exceeded in the receiving waters.

3.3.5.3 Discharge Toxicity (Hazard Index)

Because CHT does not directly release wastewater to the receiving waters within 12 nm, there is no liquid discharge to model, nor an HI to calculate at the EOMZ.

3.3.5.4 Non-Indigenous Species Release

Because CHT does not directly release wastewater to the receiving waters within 12 nm, the potential for the discharge to release NIS is nearly nonexistent.

3.3.5.5 Bioaccumulative Contaminants of Concern

Because CHT does not directly release wastewater to the receiving waters within 12 nm, essentially no BCCs are released.

3.3.5.6 Constituent Mass Loading and Toxic Pound Equivalents

Because CHT does not directly release wastewater to the receiving waters within 12 nm, this MPCD option has essentially no mass loading of constituents to the receiving waters; therefore, no TPEs were calculated.

3.3.5.7 Other Potential Environmental Impacts

The only potential impact identified for this MPCD would result from the mishandling of the collected bilgewater during the offloading and transfer to shore for disposal. The transferred bilgewater is treated at a properly permitted facility.

3.4 MPCD RANKING AND ASSOCIATED UNCERTAINTY

This section analyzes and ranks MPCD options that passed the MPCD screen and was not determined to be infeasible in the Bilgewater FIAR (Navy and EPA 2002a) for vessels with nuclear steam propulsion. Included in this section is a discussion of uncertainty and its effect on the ranking of MPCDs.

The primary-treatment MPCD options for bilgewater in nuclear steam propulsion vessels are gravity coalescence, centrifuge, and hydrocyclone. For simplification, these MPCDs were combined and represented by gravity coalescence, as described in the ChAR (Navy and EPA, 2003). CHT is also a primary MPCD option for bilgewater. Membrane filtration and filter media are secondary-treatment MPCD options that can be used in conjunction with the gravity coalescence, centrifuge, or hydrocyclone MPCD options. As with primary treatment, secondary treatment options are represented in UNDS analysis by being combined with gravity coalescence. The term “treatment train” is used when describing combinations of primary and secondary treatment MPCD options.

To analyze the environmental effectiveness of a particular MPCD option or MPCD treatment train, the results of the environmental analysis were compared to:

- Number of exceeded WQC;
- Number of constituents exceeding the strictest criteria;
- HI toxicity analysis;
- Presence of BCCs;
- Constituent mass loading and TPE;
- Potential to introduce NIS; and
- Other environmental effects.

3.4.1 Exceeded Water Quality Criteria

As discussed in the Bilgewater ChAR (Navy and EPA, 2003), there is wide variability in the composition of bilgewater. This variability is due to many factors, including variation in constituent sources (e.g., the occurrence of mechanical leakage), variation in processing rates, age of vessel and piping materials, and variations in equipment reliability. Due to these many factors, sampling was conducted only to take a “snapshot” of the bilgewater composition for the discharge to complement available process knowledge. Uncertainty due to naturally occurring variability is the primary impediment to using sample data to rank MPCD options. Therefore process knowledge is the primary source of information for this ranking.

In addition to variability, questions of data accuracy contribute to uncertainty. One important source of accuracy relates to the data used to describe primary treatment plus filter media. As discussed in the Bilgewater ChAR (Navy and EPA, 2003), filter media MPCD options will occasionally under-perform due to channeling. This phenomenon occurs as the discharge passes through areas of the media that can no longer effectively remove contaminants. The data used to describe filter media performance are based on favorable conditions and therefore may not represent a long-term average.
Table 3-21 provides a comparison of constituent concentrations to WQC values for those constituents that exceed the strictest criterion.

Table 3-21. Comparison of Discharge Constituent Concentrations (µg/L) that Exceed Numeric Water Quality Criteria in the Baseline Discharge and MPCD Discharges from Vessels with Nuclear Steam Propulsion (CVN 68) (CVN 68)

Discharge Constituent	Strictest WQC	Baseline	Primary Treatment	Primary Treatment Plus Filter Media[1]	Primary Treatment Plus Membrane Filtration[1]	CHT [2]
Cadmium	5.0E+00	5.4E+00	5.1E+00	5.1E+00	1.0E+00[3]	0
Copper	2.4E+00	2.6E+02	1.6E+02	1.6E+02	1.6E+02	0
Iron	3.0E+02	5.2E+02	4.7E+02	1.9E+02[3]	9.4E+01[3]	0
Mercury	2.5E-02	9.2E-02	5.2E-02	5.2E-02	5.2E-02	0
Nickel	8.3E+00	3.0E+02	1.7E+02	1.3E+02	1.8E+02	0
Selenium	1.0E+00	1.2E+01	ND	ND	ND	
Zinc	5.0E+01	1.6E+03	8.8E+02	5.3E+02	8.6E+02	0
Number of Constituents exceeding strictest WQC	-	7	6	5	4	0
Total Exceeded Numeric Criteria	**-**	**78**	**77**	**76**	**74**	**0**

[1] Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).

[2] CHT does not release constituents to the receiving waters.

[3] This concentration does not exceed water quality criteria.

ND = Not Detected

Sample results indicate that metals are present at concentrations that exceed acute WQC at EOP in the baseline discharge of CVN 68 Class vessel bilgewater. Process knowledge supports the presence of metals in bilgewater due to the corrosion and wear of holding tank and piping material. The seven metal constituents listed in Table 3-21 are the seven analytes for which coastal States have developed WQC. All of the baseline constituents exceed all the criteria from the various States from which criteria were collected. The cadmium values exceed only two of 13 criteria and mercury values exceed only three of 12 criteria. However, given the uncertainty in sample results, it is likely that the number of criteria exceeded by the concentration of these metals in CVN 68 Class vessel bilgewater will vary.

Baseline discharge sample results did not indicate exceedance of numeric WQC for any measured organic constituents (see Appendix A). Despite the variability of bilgewater composition, no individual organic constituent criteria is likely to be exceeded because the sampled values are all well below criteria. A class of constituents, total aqueous hydrocarbons, was measured at a level (13 µg/L) just below criteria (15 µg/L). Although this value is not in excess of criteria, it is likely that the concentration of total aqueous hydrocarbons will exceed the criterion at EOP due to the variability in composition. This conclusion is supported by process knowledge that indicates the presence of oil and grease (HEM).

The application of MPCDs (with the exception of CHT) to treat the baseline discharge did not demonstrate a significant reduction in the number of numeric WQC exceeded at EOP. The only improvement demonstrated in regard to criteria exceedance was the ability of both secondary treatment options to reduce iron values to below the single criterion that was utilized by the

UNDS program and the ability of primary treatment plus membrane filtration to reduce cadmium values to below the WQC. The reduction may be due to the affinity of metals for suspended particulate matter and subsequent removal via filtration (Putnam and Singerman, 2001).

MPCD ranking by numeric WQC exceeded:

1. CHT
2. Primary treatment plus membrane filtration
3. Primary treatment plus filter media
4. Primary treatment only

Table 3-22 provides a comparison of baseline and MPCD option characteristics to narrative WQC.

Table 3-22. Comparison of Narrative Water Quality Criteria for Baseline and MPCD Discharge Constituents for Vessels with Nuclear Steam Propulsion (CVN 68)

Narrative Constituent with Applicable Numeric Endpoint	Baseline	Primary Treatment	Primary Treatment Plus Filter Media[1]	Primary Treatment Plus Membrane Filtration[1]	CHT
BOD	Fail	Fail	Fail	Fail	Pass
Color	Pass	Pass	Pass	Pass	Pass
Floating Material	Pass	Pass	Pass	Pass	Pass
Nutrients	Fail	Fail	Fail	Fail	Pass
Odor	Pass	Pass	Pass	Pass	Pass
Oil and Grease (HEM)	Fail	Fail	Fail	Fail	Pass
Pathogens 54 enterococci/100 ml	Pass	Pass	Pass	Pass	Pass
Settleable Materials	Pass	Pass	Pass	Pass	Pass
Suspended Solids (25 mg/L)	Fail	Fail	Pass	Pass	Pass
Taste	Pass	Pass	Pass	Pass	Pass
Temperature	Pass	Pass	Pass	Pass	Pass
Turbidity / Colloidal Matter	Fail	Fail	Pass	Pass	Pass
Total Exceeded Narrative Categories	**5**	**5**	**3**	**3**	**0**

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

Sample data and process knowledge indicate that primary treatment reduces oil and grease (HEM) levels by approximately one-half, but not to below criteria endpoints. Secondary treatment further reduces these levels. Suspended solids levels change slightly between baseline and primary treatment, and drop to below criteria levels after secondary treatment. Given the uncertainty in sample data, the differences between secondary treatment options may not be significant. Characterization information did not demonstrate significant relative differences among options in terms of the other various environmental concerns evaluated by narrative criteria.

MPCD ranking by narrative WQC exceeded:

1. CHT
2. Primary treatment plus membrane filtration, or primary treatment plus filter media
3. Primary treatment only

3.4.2 Discharge Hazard Index

The UNDS program incorporates an HI approach as a means of estimating the aggregate acute toxicity of a discharge. This estimate is made by first applying a modeled dilution factor to EOP constituent sample data. The HQs are determined by dividing the product by the constituent-specific toxicological endpoint concentration (TEC). The HI is the summation of these quotients, which is used to estimate acute marine aquatic-life toxicity at the EOMZ. This analysis method is described in the EEA guidance manual (Navy and EPA, 2000e). For more information on the HI method, see the *Method for Assessing the Toxicity of Multiple Contaminants in Discharges from Vessels of the Armed Forces Uniform National Discharge Standards* (Navy and EPA, 2001b).

The uncertainty of HI values is primarily based on the uncertainty in sample data, compounded by approximations made in the computer-based modeling of the liquid discharge. For more information about the UNDS modeling method, see the *Technical Approach for Pierside Modeling to Support UNDS EEA Phase II* (Navy and EPA, 2001f).

Table 3-23 provides the calculated HI values for the baseline discharge and MPCD options as well as the EOMZ HQs for the COCs.

Table 3-23. Comparison of Constituent of Concern Hazard Quotients and Total Discharge Hazard Indices at Edge of Mixing Zone in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (CVN 68)

Discharge Constituent	Baseline	Primary Treatment	Primary Treatment Plus Filter Media[1]	Primary Treatment Plus Membrane Filtration[1]	CHT
Bis (2-Ethylhexyl) Phthalate	5.5E-04	ND	ND	ND	0
Cadmium	1.5E-02	1.4E-02	1.4E-02	2.9E-03	0
Copper	1.4E+01	8.3E+00	4.1E+00	4.8E+00	0
Oil and Grease (HEM[2])	7.2E+00	3.2E+00	9.5E-01	1.2E+00	0
Iron	2.0E-01	1.8E-01	7.3E-02	3.7E-02	0
Mercury	6.1E-03	3.3E-03	3.3E-03	3.3E-03	0
Nickel	4.8E-01	2.6E-01	2.0E-01	2.8E-01	0
Nitrate/Nitrite	5.2E-01	4.5E-01	2.7E-01	4.5E-01	0
Selenium	4.8E-03	ND	ND	ND	0
Sulfate	1.8E+00	3.2E+00	3.2E+00	3.2E+00	0
Total Sulfide	5.1E+01	3.1E+01	6.1E+00	ND	0
Zinc	2.1E+00	1.1E+00	6.8E-01	1.1E+00	0
Total Discharge HI	**7.8E+01**	**4.7E+01**	**1.6E+01**	**1.1E+01**	**0**

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001a).*

ND = Not Detected

Discharge HI calculations demonstrate an improvement in environmental benefit through each stage of the treatment train. Given the degree of uncertainty in the sample data due to naturally occurring variability, the differences between HI values for secondary treatment options are indistinct.

MPCD ranking by discharge HI:

1. CHT
2. Primary treatment plus membrane filtration, or primary treatment plus filter media
3. Primary treatment only

3.4.3 Non-Indigenous species

All of the MPCD options, with the exception of CHT, are relatively equal when considering the potential to introduce NIS to the receiving waters. CHT has essentially no potential for release because there is no direct discharge to the receiving waters inside 12 nm. The potential for the baseline discharge to introduce NIS is expected to be low because *"there is only minor seawater access to bilge compartments, and bilgewater is generally processed before it is transported over long distances"* (EPA and DoD, 1999).

MPCD ranking by potential to release NIS:

1. CHT
2. Primary treatment plus membrane filtration, or primary treatment plus filter media
3. Primary treatment only

3.4.4 Bioaccumulative Contaminants of Concern

Table 3-24 provides a comparison of the number of elimination and reduction BCCs identified in the discharge across MPCDs. BCCs in the discharges are also indicated by an asterisk (*) in Appendices A and B.

Table 3-24. Comparison of Bioaccumulative Contaminants of Concern Identified in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (CVN 68)

Discharge	Elimination BCCs	Reduction BCCs	Total BCCs
Collection, Holding, and Transfer (CHT)	0	0	0
Primary Treatment plus Filter Media[1]	2	2	4
Primary Treatment plus Membrane Filtration[1]	2	2	4
Primary Treatment	2	2	4
Baseline discharge	2	4	6

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

Sample data demonstrated that one BCC, Bis (2-ethylhexyl) phthalate (a reduction BCC), was reduced to levels below detection after MPCD treatment. Differences among MPCD options outside of CHT were not evident.

MPCD ranking by presence of BCCs:

1. CHT
2. Primary treatment only, primary treatment plus membrane filtration, primary treatment plus filter media

3.4.5 Constituent Mass Loading and Toxic Pound Equivalents

As discussed in the EEA guidance manual (Navy and EPA, 2000e), mass loading and TPEs were calculated for each discharge constituent. Both the mass loading and TPE calculations are functions of the constituent concentrations and annual discharge volumes. The uncertainty associated with the constituent concentration values is due to the naturally occurring variability in bilgewater composition, as described in Section 3.4.1.

As discussed in the Bilgewater ChAR (Navy and EPA, 2003), the UNDS Phase I Surface Vessel Bilgewater/OWS Nature of Discharge report (NOD) estimates that the average in-port generation rate for a CVN class vessel is approximately 3,000 gal/day (EPA and DoD, 1999). However, actual performance data indicates the generation rate is 17,000 gal/day in port and 68,000 gal/day underway (Navy, 1997). Additionally, the two vessel classes that comprise this vessel group are similar in vessel size, machinery, and displacement. Unlike other discharges, the bilgewater generation rates do not depend on crew size, but rather ship size and propulsion plant type.

For more information about the uncertainty associated with the generation rates, see the Bilgewater ChAR (Navy and EPA, 2003). The ChAR provides details on the assumptions made to determine the generation rate; specifically, that all of the bilgewater generated pierside is discharged overboard. In practice, however, bilgewater generated by the CVN 68 Class vessels is typically treated at a shoreside facility.

Mass loading data for the baseline discharge and each MPCD option are summarized in Table 3-25.

Table 3-25. Comparison of Discharge Constituents of Concern Mass Loading (lbs/yr) in Baseline and MPCD Discharges from Vessels with Nuclear Steam Propulsion (CVN 68)

Discharge Constituent	Baseline	Primary Treatment	Primary Treatment Plus Filter Media[1]	Primary Treatment Plus Membrane Filtration[1]	CHT[2]
Bis (2-Ethylhexyl) Phthalate	5.5E+00	ND	ND	ND	0
Cadmium	1.3E+00	1.3E+00	1.3E+00	2.5E-01	0
Copper	1.4E+02	8.4E+01	4.2E+01	4.8E+01	0
Oil and Grease (HEM[3])	1.3E+04	5.7E+03	1.7E+03	2.1E+03	0
Iron	1.3E+02	1.1E+02	ND	ND	0
Mercury	2.2E-02	1.3E-02	1.3E-02	1.3E-02	0
Nickel	7.4E+01	4.1E+01	3.1E+01	4.3E+01	0
Nitrate/Nitrite	1.3E+02	6.6E+01	4.0E+01	6.6E+01	0
Selenium	2.8E+00	ND	ND	ND	0
Sulfate	1.2E+05	2.2E+05	2.2E+05	2.2E+05	0
Total Sulfide	2.1E+03	1.2E+03	2.5E+02	ND	0
Zinc	4.0E+02	2.1E+02	1.3E+02	2.1E+02	0

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

[2] *CHT does not release constituents to the receiving waters.*

[3] *HEM TEC value was based on the fuel/lube TEC. For more information, see* Development of TECs for Categories of Oily Substances Derived from Petroleum and Foods *(Navy and EPA, 2001a).*

ND = Not Detected

MPCD options were not ranked by mass loading values because they would have to be ranked for every constituent separately. In order to capture the net chronic toxic effect of mass loading contributions, the relative toxicity of each constituent would have to be weighted. In order to achieve a relative ranking, TPEs were utilized. Table 3-26 provides the TPEs for the baseline discharge and MPCD options for this vessel group.

Table 3-26. Comparison of Toxic Pound Equivalents for the Baseline Discharge and MPCD Discharges from Vessels with Nuclear Steam Propulsion (CVN 68)

Discharge	Toxic Pound Equivalent
Collection, Holding, and Transfer (CHT)	0

Primary Treatment plus Membrane Filtration[1]	2.1E+02
Primary Treatment plus Filter Media[1]	8.8E+02
Primary Treatment	3.7E+03
Baseline Discharge	6.1E+03

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

The total discharge TPE does not include the chronic toxicity contribution from oil and grease (HEM) constituents, however, because the individual constituents of this fraction vary by products entering the bilge and the degree of product weathering before discharge. The chronic toxicity contributions were therefore evaluated by comparing to HQ and HI results. As discussed in Sections 3.3.1.6, 3.3.2.6, 3.3.3.6, and 3.3.4.6, oil and grease (HEM) constituents are assumed to contribute approximately six percent to eleven percent of total chronic toxicity in discharges, based on acute toxicity (HI) determinations.

Overall, TPE calculations for the baseline and MPCD options indicate that primary treatment provides an approximately 39 percent reduction in equivalent toxic mass discharged. Filter media technology was shown to reduce the TPE levels in primary treatment discharge by an additional 76 percent to achieve an 86 percent reduction overall. Membrane filtration was shown to reduce the TPE to an overall 97 percent reduction by removing total sulfides to levels below detection.

MPCD ranking by TPE:

1. CHT
2. Primary treatment plus membrane filtration
3. Primary treatment plus filter media
4. Primary treatment only

3.4.6 Other Potential Environmental Impacts

Most MPCDs create two waste streams: the aqueous fraction that is discharged overboard following treatment and the oil fraction that is directed to the on-board waste-oil holding tank. The oil fraction is treated at a properly permitted facility and subject to applicable Federal, State, and local disposal regulations. The use of filter media creates an additional waste in the form of used filters. Disposal of these used components is subject to Federal, State, and local disposal regulations. For purposes of this analysis, the disposal of these discharges is assumed to comply with applicable regulations. The MPCD options described in this analysis of bilgewater are therefore ranked as equivalent options in terms of other environmental impacts.

3.4.7 Conclusion

The results of the EEA for the baseline and MPCD bilgewater discharges from vessels with nuclear steam propulsion are summarized in Table 3-27.

Table 3-27. Summary of EEA for Baseline and MPCD Bilgewater Discharges from Vessels with Nuclear Steam Propulsion (CVN 68)

	Baseline	Primary Treatment	Primary Treatment Plus Filter Media[1]	Primary Treatment Plus Membrane Filtration[1]	CHT
Number of Constituents exceeding strictest WQC	7	6	5	4	0
Total Number of Exceeded Numeric WQC	78	77	76	74	0
Number of Exceeded Narrative Categories	5	5	3	3	0
Discharge HI at EOMZ	7.8E+01	4.7E+01	1.6E+01	1.1E+01	0
Potential for NIS Release	Low	Low	Low	Low	None
Number of BCCs Identified	6	4	4	4	0
Discharge TPE	6.1E+03	3.7E+03	8.8E+02	2.1E+02	0

[1] *Constituent concentrations are calculated using methodology described in Putnam and Singerman (2001).*

In summary, the application of CHT to bilgewater has the least environmental impact because there is no direct discharge to the receiving water within 12 nm. The secondary treatment options provide bilgewater treatment performance that is equal or superior, for each of the analysis methods (e.g., criteria exceedance, HI, and TPE), to primary treatment alone. Given the uncertainty associated with sample data, the environmental effects analysis could only distinguish between the two secondary treatment options by TPE ranking. Primary treatment is expected to result in fewer deleterious environmental effects than the baseline discharge.

MPCD ranking by overall environmental effect:

1. CHT
2. Primary treatment plus membrane filtration
3. Primary treatment plus filter media
4. Primary treatment only